Systematic Study of Particle Production at High p_T with the PHENIX Experiment at RHIC

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Abstract. The PHENIX experiment at RHIC has analyzed a wealth of data for different particle species, collision energies ($\sqrt{s_{NN}}$ = 62.4, 130, 200 GeV) and collision systems (p+p, d+Au, Cu+Cu, Au+Au) allowing a detailed study of particle production at high p_T. A selection of new results on single particle spectra is presented.

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Previous measurements of the nuclear modification factor R_{AA} at RHIC have shown both a strong suppression of π^0 and charged-hadron yields in central Au+Au collisions for p_T > 5 GeV/c at mid rapidity independent of p_T and particle species [1, 2], and an enhanced proton yield (relative to pions) at intermediate p_T (2-5 GeV/c) [3]. The dependence on p_T and on the particle species reflect the detailed interplay between jet quenching and other effects such as flow and recombination.

Recently the PHENIX experiment could extend the p_T reach of π^0's in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV by a high statistics run (RHIC Run-4). Figure 1 (left) shows R_{AA} for π^0's, η's and direct γ's as a function of p_T for central Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. While direct γ's are unsuppressed compared to the T_{AA}-scaled

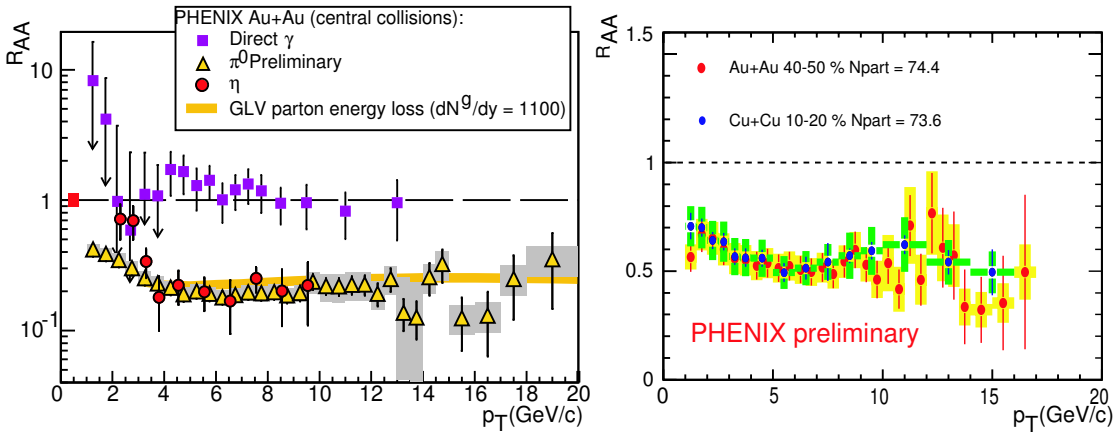

FIGURE 1. (left) R_{AA} for π^0's, η's and direct photons as a function of p_T for central Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. (right) R_{AA} for π^0's in Cu+Cu and Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV for a similar number of participants. The error bars include all point-to-point errors, in case of error boxes or the error band at R_{AA} = 1 these errors have to be added.

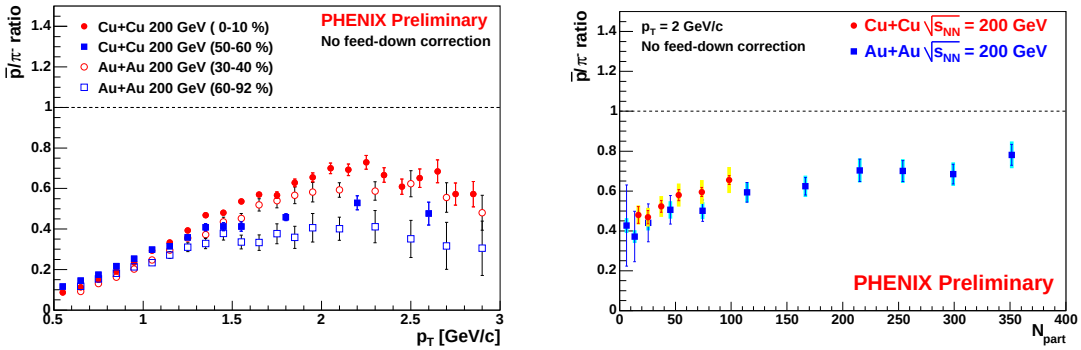

FIGURE 2. $\overline{p}/\pi^-$ ratio as a function of p_T (left) and as a function of N_{part} at p_T = 2 GeV/c (right) in Cu+Cu and Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. Corrections for feed-down from weak decays are not applied.

reference [4] (with $\langle N_{coll}\rangle \equiv \langle T_{AA}\rangle \cdot \sigma_{pp}^{inel}$), π^0's and η's are similarly suppressed by a factor of $\sim$5 compared to the corresponding cross-sections measured in $p+p$. This shows that within current uncertainties, light-quark mesons at RHIC show a common suppression, independent of their mass (the η is four times heavier than the π^0). The suppression for π^0's is almost constant even up to the highest p_T measured. The results are in agreement with expectations of energy loss effects with initial gluon densities in the order of $dN^g/dy \approx 1100$ (yellow curve in Fig. 1) [5].

The recently measured Cu+Cu data sets allow the study of the influence of the collision system on particle production at high p_T. Fig. 1 (right) shows R_{AA} for π^0's in Cu+Cu and Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV for centrality selections with a similar number of participants N_{part}. The N_{part} value is associated with the centrality using a Glauber model calculation. It can be seen that π^0's are suppressed by a similar factor for similar N_{part} in the two systems.

An N_{part}-scaling behavior can also be seen in the enhancement of the proton to pion ratio at intermediate p_T (2-5 GeV/c) that was first observed in Au+Au collisions at RHIC. Figure 2 (left) shows a comparison of the $\overline{p}/\pi^-$ ratio in Cu+Cu and Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV as a function of p_T for centrality selections with a similar number of participants. Figure 2 (right) shows the same ratio as a function of N_{part} calculated at p_T = 2 GeV/c. The data shows similar p_T and system-size (N_{part}) dependences in Cu+Cu and Au+Au, with a slight difference in the magnitude. The N_{part}-scaling behavior is also seen in p/π^+ and K/π ratios (not shown).

To study the dependence of particle production on the beam energy, additional data at $\sqrt{s_{NN}}$ = 62.4 GeV was taken. This lower-energy data provides important information on baryon production at an energy between SPS and RHIC. Figure 3 shows the p/π^+ and $\overline{p}/\pi^-$ ratios in central Au+Au collisions at 62.4 GeV and 200 GeV as a function of p_T. In comparison to the particle ratios at 200 GeV, the ratios at 62.4 GeV show a slightly larger proton contribution at intermediate p_T but a smaller antiproton contribution. Possible explanations for the larger ratio of p/π include the larger difference between the slopes of spectra from fragmentation and recombination processes at 62.4 GeV than that at 200 GeV [6].

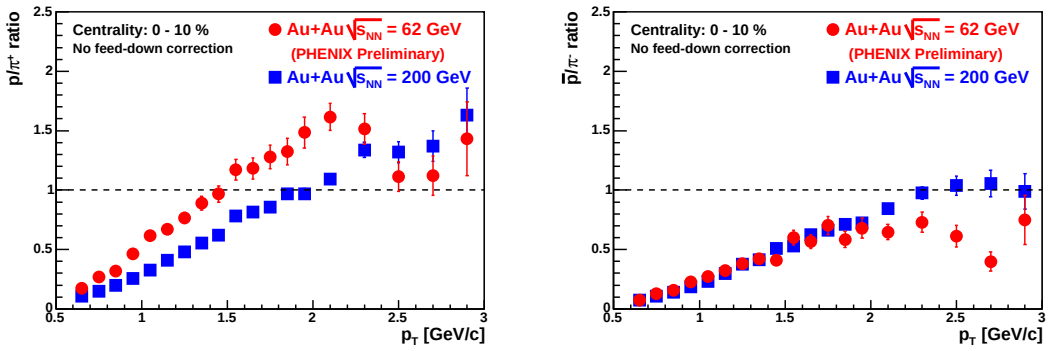

FIGURE 3. p/π^+ (left) and $\overline{p}/\pi^-$ (right) ratios in central (0-10%) Au+Au collisions at $\sqrt{s_{NN}}$ = 62.4 GeV and 200 GeV. The feed-down corrections from weak decays are not applied.

SUMMARY

New results on single particle production in Au+Au collisions at $\sqrt{s_{NN}}$ = 62.4 and 200 GeV and Cu+Cu collisions at $\sqrt{s_{NN}}$ = 200 GeV are presented. In Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV direct γ's are unsuppressed compared to the T_{AA}-scaled $p+p$ reference, π^0's and η's are suppressed by the same magnitude (factor $\sim$5). The suppression for π^0's is almost constant even up to the highest p_T measured and in agreement with model calculations of energy loss effects ($dN^g/dy \approx 1100$).

Both, R_{AA} for π^0's and the p/π ratio, show an N_{part} scaling behaviour in a comparison of particle production in Au+Au and Cu+Cu collisions at $\sqrt{s_{NN}}$ = 200 GeV.

The enhanced p/π ratio at intermediate p_T is observed in all collision systems: In comparison to the particle ratios at 200 GeV, the ratios at 62.4 GeV show a slightly larger proton contribution at intermediate p_T but a smaller antiproton contribution.

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